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VALIDATION OF THE ARISCAT SCORE FOR PREDICTING POSTOPERATIVE PULMONARY COMPLICATIONS IN PATIENTS WITH CHRONIC RESPIRATORY DISEASES: A TERTIARY CARE CENTER EXPERIENCE FROM PAKISTAN

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Abstract

Background: *Postoperative pulmonary complications (PPCs) contribute substantially to perioperative morbidity in patients with chronic respiratory disease. This study evaluated the frequency, risk factors, and predictive value of the ARISCAT score in high-risk populations,*

Methods: *A prospective observational study was conducted from September 2023 to September 2024 at Aga Khan University Hospital in Karachi, Pakistan. Adult patients undergoing perioperative pulmonary consultation for non-cardiothoracic surgery were enrolled. Data on demographics, comorbidities, spirometry, chest radiographs, surgical procedure details, and ARISCAT scores were collected. PPCs were defined using European Perioperative Clinical Outcome criteria.*

Results: *Among 140 patients (median age 65 years, 65.7% female), PPCs occurred in 25.7%. The rate was higher in COPD (38.6%) compared with non-COPD patients ($p = 0.031$), while asthma patients had a PPC rate of 24.4% ($p = 0.976$). Active smokers had significantly higher PPC rates (52.6%) than former (33.3%) or never smokers (19.4%) ($p = 0.007$). No significant association was found between PPCs and preoperative steroid use, abnormal chest radiographs, or spirometry (FEV_1 % predicted). Significant predictors on univariate analysis included COPD, active smoking, lower preoperative SpO_2, and prolonged surgery. The ARISCAT score demonstrated good discrimination with AUC 0.730 (95% CI 0.633–0.826),and PPC rates of 64.0%, 24.6%, and 6.5% in high-, intermediate-, and low-risk categories, respectively.*

Conclusions: *PPC risk was significantly higher in COPD patients and active smokers. Preoperative steroid use, abnormal chest radiographs, and spirometry were not predictive. The ARISCAT score effectively stratified risk and may aid targeted perioperative optimization.*

INTRODUCTION

Post-operative pulmonary complications (PCCs) occur in an estimated 5%-10% of all surgeries, with incidence varying from 1% to 23% in major surgeries(1). Various definitions exist in literature,

and broadly encompass pulmonary issues in the postoperative period which can result in identifiable disease and clinically significant dysfunction(2). PCCs can manifest as minor complications such as atelectasis or as respiratory failure requiring invasive mechanical support(1). Identifying risk factors for PCCs can be challenging, as they can be both patient and procedure-related, especially in high-risk populations. Preoperative risk stratification is paramount in identification of patients at high risk of developing (PCCs) and guides both management and patient counselling, particularly in view of the informed consent. Patients with chronic respiratory diseases, including asthma, chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), and post-tuberculosis lung sequelae, are at particularly high risk due to reduced pulmonary reserve, baseline airway inflammation, and impaired mucociliary clearance. In such patients, postoperative factors such as pain-limited breathing, anesthesia-induced hypoventilation, and prolonged immobility can further exacerbate the likelihood of PPCs.

Identifying risk factors in this subgroup is especially important, as they may require tailored perioperative optimization strategies.Previous studies on the predictive value of preoperative investigations such as pulmonary function tests/spirometry, arterial blood gas analysis, and chest x-ray findings have yielded inconsistent results. Whereas, a simple, clinical parameter, preoperative oxygen saturation at room air was found to be useful in the predication model developed by Canet et al (3)and in the subsequent external validation study by Mazo et al(4). Prediction models for PCCs have varied results due to differences in study protocols, retrospective study designs, variable definition of PCC or exclusion of certain perioperative risk factors, particularly related to intra-operative anesthesia and ventilatory parameters. Furthermore, most developed scoring systems are based on population/ setups in the developed countries and have not been validated in populations in developing countries which may have different population dynamics and health care resources. The ARISCAT score (The Assess Respiratory Risk in Surgical Patients in Catalonia) was developed by Canet et al (5)based on seven clinically significant independent variables identified through a multivariable regression model. The ARISCAT score has been externally validated by the PERISCOPE study (Prospective Evaluation of a Risk Score for Postoperative Pulmonary Complications in Europe), and recent studies have reported similar predictive value (6–9) .

PPC can result in significant patient morbidity, increase in length of hospital stay(LOS) and increase in mortality rate, both short-term(10) (30-day and 90-day mortality) and long term, even up to 5 years. A study conducted in Mexico predicted that combining spirometry with the ARISCAT model resulted in an Incremental Cost-Effectiveness Ratio (ICER) of -$11,568 compared to using the ARISCAT score alone.(11).

Only a few studies have evaluated the rate of PPCs rate in the Pakistani population. Naveed et al(12) reported a PCC rate of 6.2% in patients undergoing coronary artery bypass grafting (CABG), and Alam et al. (11) reported PCCs in 8.1% of patients undergoing cardiac surgery. (13). Moreover, risk factors particularly predictive of the PPC in Pakistani patients have not been identified and prediction models have not been validated in our population. Identification of those at risk of developing PCC and implementing measures to decrease them can result in substantial reduction in undue health care expenditures and health care costs. Since most PPCs occur in elderly patients, and Pakistan is now developing an increasing population in elderly strata accurately predicting and managing these complications becomes crucial, especially in high-risk surgeries. Implementing post-operative monitoring, care, and rehabilitation strategies tailored to these patients can significantly reduce LOS, morbidity and mortality rates.

Therefore, this study aimed to evaluate the rate of PCCs in a large tertiary care setup in Pakistan and identify the preoperative risk factors associated with the development of these complications. Discrimination value of ARISCAT score in predicting the PCC was also evaluated.

METHODOLOGY

A prospective observational study was conducted in the Aga Khan University Hospital Karachi, after approval from ethical review committee(ERC 2023-9181-26144) from September 2023 to September 2024. Adult Patients between the ages of 18-80 years who underwent perioperative pulmonary

consultation for non-cardiothoracic surgeries were enrolled using non-probability consecutive sampling

Exclusion Criteria:

1. Surgery/Procedure duration > 8 hours
2. Patients intubated prior to surgery/procedure.
3. Life-threatening condition/Trauma surgeries
4. Pregnant patients
5. Neuromuscular conditions resulting in impaired cough/gag reflex
6. Incomplete records

Study Population and Data Collection: Male and female patients, who underwent pre-procedure risk stratification for post-operative pulmonary complications as per pre-operative requirement fulfilling inclusion criteria were included. For data collection, charts and electronic records of respective patients was reviewed and relevant information was collected regarding 1) patient related factors- age, gender, BMI, co-morbid conditions 2) Procedure related factors- Site, duration, Nature, Bleeding risks,3) Post-operative factors. ARISCAT score(5) were calculated and classified as: Low risk: < 26, intermediate risk: 26–44, and High risk: ≥45.

Variable		Points
Age, years	≤50	0
	51-80	3
	>80	16
Preoperative SpO_2	≥96%	0
	91-95%	8
	≤90%	24
Respiratory infection in the last month	No	0
	Yes	17
Preoperative anemia (Hgb ≤10 g/dL)	No	0
	Yes	11
Surgical incision	Peripheral	0
	Upper abdominal	15
	Intrathoracic	24
Duration of surgery	<2 hrs	0
	2-3 hrs	16
	>3 hrs	23
Emergency procedure	No	0
	Yes	8

Postoperative pulmonary complication were defined as the occurrence of at least one event on of in-hospital fatal or nonfatal PPCs as per The European Perioperative Clinical Outcome Definitions (EPCO.) These included: Respiratory Failure, Respiratory infection, Aspiration Pneumonia, Pleural effusion, Pneumothorax, Atelectasis, Bronchoconstriction, Pneumonia, ARDS, Pulmonary Embolism, Pulmonary Edema, Unplanned emergency re-intubation, Leaving as intubated from the operation room. Primary outcomes were occurrence of PCC and in-hospital mortality. Secondary outcomes were include length of stay and morbidity attributable to PCC.

Ethical considerations: Identifiers were not collected, and patients were given unique identity numbers to maintain confidentiality. For aforementioned data collection no additional consent was be applicable as no extra intervention/interaction was required with patients, data was collected from the pre-operative risk stratification notes, post-operative notes and discharge summaries.

Data Analysis:
Data entry and analysis was done in SPSS version 26. Continuous variables were described as mean ± standard deviation, or median with interquartile ranges; and categorical variables were expressed as percentages. Normality of data was checked using Shapiro-Walk test. Normally and abnormally distributed quantitative variables were compared using the Student's t-test and the Mann-Whitney U test, respectively. Chi-square test for categorical data comparison. P-value< 0.05 will be taken as significant. Area Under curve for the ARISCAT score; ASA scores was determined using receiver operating curve analysis, Sensitivity, specificity, Positive predictive value, and Negative predictive value were calculated for different cutoffs.

Results:
A total of 140 patients were included in the study. Median age was 65 (IQR 55–74 years), and majority were females (65.7%). Most common surgical procedures were in the orthopedic category. Further details in Table-1.

Table-1 Baseline clinical characteristics

Variable	Summary
Age, years Median (IQR)	**65 (IQR 55–74 years)**
Gender	
Female	92 (65.7%)
Male	48 (34.3%)
Surgical procedure	
Orthopedic	59 (42.1%)
Abdominal	39 (27.9%)
Spinal	17 (12.1%)
Head & Neck	11 (7.9%)
Breast	9 (6.4%)
Chronic respiratory disease	
COPD	44 (31.4%)
Asthma	45 (32.1%)
Interstitial lung disease	11 (7.9%)
Post-TB fibrosis	11 (7.9%)
Obstructive sleep apnea	6 (4.3%)
OSA/OHS	5 (3.6%)
Others	5 (3.6%)
Median FEV1(% predicted) N=48	58.0 (47.0–71.5)
Co-morbid conditions	
Cardiovascular comorbidity	25 (17.9%)
Diabetes	51 (36.4%)
Hypertension	88 (62.9%)
Malignancy	16(11.4%)
Previous surgical history	66 (47.1%)
Previous postoperative complications	5 (3.6%)
Functional status	

Partially independent	89 (63.6%)
Independent	44 (31.4%)
Totally dependent	7 (5.0%)

Postoperative pulmonary complications (PPCs) occurred in 36 patients (25.7%)(Table-2). Median ARISCAT scores were significantly higher in patients with PPCs compared to those without PPCs (median [IQR]: 35.5 [27.0–54.8] vs. 28.0 [15.0–34.0]; $p < 0.001$). General anesthesia was administered to 107 patients, with a PPC rate of 28.0% (30/107), while 33 patients underwent spinal anesthesia, with a PPC rate of 9.1% (3/33) ($p = 0.024$). Overall, the 30-day mortality rate was 2.9%, and 5.7%(8) patients required re-admission, two due to surgical site infections, two due to major adverse cardiac events three due to respiratory complications(exacerbation) and one patient developed pulmonary embolism. The complication rates for high, intermediate, and low ARISCAT risk groups were 64.0% (16/25), 24.6% (17/69), and 6.5% (3/46), respectively.

Table-2 Post-operative pulmonary complications and outcomes

Outcome	**n (%) or Median (IQR)**
Overall complication rate	36 (25.7)
Median (IQR) number of PPC	2 (1-2)
Types of complications	
Respiratory failure	16 (11.4)
Atelectasis	15 (10.7)
Hypoxia	14 (10.0)
Hypercapnic failure	14 (10.0)
Exacerbation	12 (8.6)
Bronchospasm	10 (7.1)
Pulmonary edema	7 (5.0)
Pneumonia	3 (2.1)
Reintubation	3 (2.1)
Pneumothorax	1 (0.7)
Pulmonary embolism	1 (0.7)
Hospital acquired pneumonia	1 (0.7)
Escalation of care	10(7.1)
Invasive MV (leaving intubated from OR)	5 (3.6)
Non-invasive mechanical ventilation	14 (10.0)
In-hospital mortality	2 (1.4)
30-day mortality	4(2.9)
Readmission	8 (5.7)
Length of stay (LOS) post-op (days)	3.0 (2.0)
Total LOS (days)	4.0 (3.0)

Among the study cohort, the most common chronic respiratory conditions were asthma and COPD, present in 32.1% and 31.4% of patients, respectively, while 7.9% had interstitial lung disease (ILD). Only COPD was significantly associated with a higher rate of postoperative pulmonary complications, occurring in 38.6% of patients with COPD (p = 0.031). No statistically significant association was observed between GOLD stage and PPC incidence (p = 0.616). In patients with COPD, a lower PPC rate was observed in those receiving preoperative steroids (35.0% vs 47.4%), although this difference was not statistically significant (p = 0.433). In patients with asthma, preoperative corticosteroids administration was associated with a higher PPC rate (27.6% vs 8.3%), although this difference was not statistically significant (p = 0.175). The higher complication rate among steroid recipients may reflect confounding by indication, as patients with more severe asthma were more likely to receive perioperative steroids.

Among asthma patients, 13.3% (6/45) were high risk, 44.4% (20/45) intermediate risk, and 42.2% (19/45) low risk, with corresponding complication rates of 66.7% (4/6), 25.0% (5/20), and 10.5% (2/19), respectively. Among COPD patients, 29.5% (13/44) were high risk, 45.5% (20/44) intermediate risk, and 25.0% (11/44) low risk, with corresponding complication rates of 69.2% (9/13), 35.0% (7/20), and 9.1% (1/11), respectively. On univariate analysis, active smokers had a higher complications rate, and no differences were observed in treatment with preoperative systemic steroids use. The median smoking pack-year index for the cohort was 25.0 (IQR: 20.0–40.0). Patients who developed postoperative pulmonary complications (PPCs) had a median pack-year index of 24.0 (IQR: 20.0–41.2), compared with 25.0 (IQR: 20.0–37.5) in those without PPCs (p = 0.920).

Table-3 Univariate analysis of post-operative pulmonary complications

Variable	Category	% (n) overall	% with PPC (n)	% without PPC (n)	P-value
Chronic Respiratory disease					
	Asthma	32.1% (45)	24.4% (11)	75.6% (34)	0.9764
	COPD	31.4% (44)	38.6% (17)	61.4% (27)	0.0308
	ILD	7.9% (11)	18.2% (2)	81.8% (9)	0.7287
	Post-TB fibrosis/sequela	7.9% (11)	9.1% (1)	90.9% (10)	0.2888
	OSA	4.3% (6)	83.3% (5)	16.7% (1)	0.0044
Smoking status					
	Active	13.6% (19)	52.6% (10)	47.4% (9)	0.0071
	Former	12.9% (18)	33.3% (6)	66.7% (12)	
	Never	73.6% (103)	19.4% (20)	80.6% (83)	
Pre-operative corticosteroid use		47.9% (67)	20.9% (14)	79.1% (53)	0.3653
Surgical procedure					
	Abdominal	27.9% (39)	33.3% (13)	66.7% (26)	0.1949

	Breast	6.4% (9)	0.0% (0)	100.0% (9)	
	Head and Neck	7.9% (11)	9.1% (1)	90.9% (10)	
	Misc	3.6% (5)	40.0% (2)	60.0% (3)	
	Orthopedic	42.1% (59)	23.7% (14)	76.3% (45)	
	Spinal	12.1% (17)	35.3% (6)	64.7% (11)	
ASA Classification					
	ASA I	1.4% (2)	50.0% (1)	50.0% (1)	0.0919
	ASA II	35.0% (49)	16.3% (8)	83.7% (41)	
	ASA III	62.9% (88)	29.5% (26)	70.5% (62)	
	ASA IV	0.7% (1)	100.0% (1)	0.0% (0)	
Emergency surgery					
	No	95.7% (134)	24.6% (33)	75.4% (101)	0.1766
	Yes	4.3% (6)	50.0% (3)	50.0% (3)	
Duration of surgery					
	2–3 hours	53.6% (75)	36.0% (27)	64.0% (48)	<0.001
	<2 hours	43.6% (61)	8.2% (5)	91.8% (56)	
	>3 hours	2.9% (4)	100.0% (4)	0.0% (0)	
Surgical incision site					
	Intrathoracic	0.7% (1)	0.0% (0)	100.0% (1)	0.8368
	Peripheral	75.0% (105)	25.7% (27)	74.3% (78)	
	Upper abdominal	24.3% (34)	26.5% (9)	73.5% (25)	
Preoperative anemia					
	Hb >10	77.9% (109)	25.7% (28)	74.3% (81)	1.0000
	Hb <10	22.1% (31)	25.8% (8)	74.2% (23)	
Respiratory infection (last month)					
	Infection	22.9% (32)	31.2% (10)	68.8% (22)	0.5582
	None	77.1% (108)	24.1% (26)	75.9% (82)	
Age category					
	<50 years	15.7% (22)	13.6% (3)	86.4% (19)	0.3492
	51–80 years	70.0% (98)	28.6% (28)	71.4% (70)	
	>80 years	14.3% (20)	25.0% (5)	75.0% (15)	
Preoperative oxygen saturation	Preoperative SpO_2				

	≥96%	63.6% (89)	14.6% (13)	85.4% (76)	0.0003
	91–95%	20.0% (28)	42.9% (12)	57.1% (16)	
	≤90%	16.4% (23)	47.8% (11)	52.2% (12)	
ARISCAT risk category					
	High (>45)	17.9% (25)	64.0% (16)	36.0% (9)	<0.001
	Intermediate (26–44)	49.3% (69)	24.6% (17)	75.4% (52)	
	Low (<26)	32.9% (46)	6.5% (3)	93.5% (43)	
	Median ARISCAT scores	31.0 [19.0–39.2]	35.5 [27.0–54.8]	28.0 [15.0–34.0]	

ILD: Interstitial Lung Disease,OSA: Obstructive sleep apnea, ASA: American Society of Anesthesiologists Classification

Preoperative chest X-ray findings were normal in 88 patients (62.9%). Abnormal findings were present in 52 patients (37.1%), most commonly atelectasis ± effusion/infiltrates in 14 patients (10.0%), followed by fibrocystic changes in 9 (6.4%), bronchiectasis in 3 (2.1%), pulmonary edema in 1 (0.7%), consolidation or infiltrates in 4 (2.9%), and nodules, masses, or metastases in 5 (3.6%). Other abnormalities, including hyperinflation, congestion, post-tuberculosis changes, diaphragm elevation, and other miscellaneous findings, were observed in 16 patients (11.4%). Among patients with a normal preoperative chest X-ray, 22.7% (15/66) developed PPCs, compared to 28.8% (17/59) of those with an abnormal chest X-ray. This difference was not statistically significant.

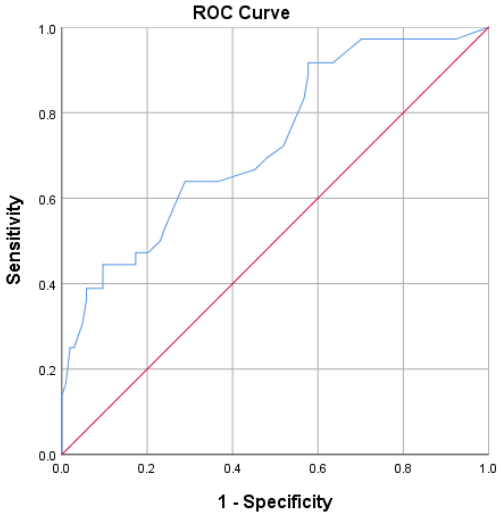

Figure-1 The area under the ROC curve for ARISCAT score

The ARISCAT score demonstrated good discriminatory ability for predicting postoperative pulmonary complications, with an area under the Receiver Operating Characteristic(ROC) curve (AUC) of 0.730 (Standard Error = 0.049, 95% CI: 0.633–0.826, p < 0.001).

Table 4- Diagnostic performance of ARISCAT score cut-off values for predicting postoperative pulmonary complications

Cut-off (score ≥)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	p-value
26.0 (low)	88.9% (73.9–96.9)	42.3% (32.7–52.4)	34.8% (25.1–45.4)	91.7% (80.0–97.7)	0.0005
31.0 (median)	66.7% (49.0–81.4)	54.8% (44.7–64.6)	33.8% (23.0–46.0)	82.6% (71.6–90.7)	0.0334
34.0 (Youden-opt)	63.9% (46.2–79.2)	71.2% (61.4–79.6)	43.4% (29.8–57.7)	85.1% (75.8–91.8)	0.0003
45.0 (high)	44.4% (27.9–61.9)	90.4% (83.0–95.3)	61.5% (40.6–79.8)	82.5% (74.2–88.9)	<0.0001

Discussion:

The overall PPC rate in this cohort was 25.6%, consistent with prior studies in high-risk surgical populations. This underscores the persistent burden of respiratory morbidity despite advances in perioperative care. Few studies have evaluated ARISCAT score in patients with chronic respiratory disease. Ramkumar et al(14) reported PPC rate of 22.9% among COPD patients who underwent elective abdominal surgery, the most common PPC was respiratory failure. Fatima et (15) in a study from Pakistan reported the prevalence of postoperative pulmonary complications in 19.6% patients with COPD. 14.84% patients with COPD developed PPC after undergoing open abdominal surgeries in another study in India by Prasad et al (16). Kim et al reported 17.3% of COPD patients experienced postoperative complications. A higher PPC frequency of 37.5% was reported by Arrieta et al(17) in cohort without chronic respiratory diseases. and the most frequent PPC was respiratory failure. Garg et al(18) from India reported 20.3% PPC rate.

Numata et al.(19) reported a similar complication rate of 8.6% in patients with asthma and 7.9% in those with COPD. In contrast, our study observed a statistically significant higher rate of PCC in patients with COPD. Numata et al. also reported a lower PCC rate in asthma patients who had received perioperative corticosteroids; however, no such association was observed in our cohort. Gupta et al reported a lower 5% incidence of PPCs in patients undergoing non-cardiac surgery(20). A lower incidence was also observed in the PERISCOPE study(5), which reported postoperative pulmonary complication (PPC) rates of 5%. Another large cohort study of patients undergoing non-cardiac surgery by Mazo et al.(4) reported a 7.9% incidence.

The ARISCAT score showed good predictive performance (AUC = 0.730), aligning with findings from other international validation studies. Arrieta et al. (17)reported an AUC of 0.7867 (95% CI: 0.737–0.834), Mazo et al. (4) an AUC of 0.80 (95% CI: 0.78–0.82), and Canet et al.(5) also reported an AUC of 0.80. In the high-risk category, the observed sensitivity in their study was 77.1% with a specificity of 67.9%. However, in our study, sensitivity was lower at 44.4% but specificity was higher at 90.4%. Kokotovic et al.(6) reported an AUC of 0.83 (95% CI: 0.79–0.86) among 585 Danish patients undergoing emergency abdominal surgery. Cardiothoracic surgeries were excluded in our study. A lower AUC of 0.60 (95% CI: 0.55–0.65) has been reported in previous research by Vaca et al(21) in patients undergoing lung resection. Shaik et al(22). from India reported an area under the ROC curve for the ARISCAT score in their study population of 0.86 (95% CI: 0.79–0.93).

Although median pack-year index did not differ significantly between groups, active smoking was associated with higher PPC rates, highlighting the need for smoking cessation strategies. Gutiérrez (11)reported similar higher rate in active smokers, Gupta et al. (20)did not find an association between smoking and PPCs. Numata et al.(19) reported a significant association with a smoking history of ≥20 pack-years; however, there was no significant difference between former and current smokers in the incidence of PPCs. Smoking status was found to have statistical significance in the study by Ramkumar et al.(14), while Lugg et al. reported that current smokers had a higher frequency of PPCs compared to non-smokers (22% vs. 2%, p = 0.004)(23). Lower baseline SpO_2 (<96%) was strongly associated with PPCs, suggesting that even mild preoperative hypoxemia warrants closer perioperative respiratory optimization.

Median predicted FEV_1 was not a predictor of PPC, and no statistically significant difference was observed among different GOLD grades in COPD. Kim et al. (24)also reported no differences in median FEV_1 values; however, statistically significant differences in PPC rates were observed across GOLD grades. Prasad et al(16) also reported higher PPC in GOLD grade 3 and 4.Gutiérrez et al(11) had reported a significantly greater incidence of POC (14% vs. 9%, respectively) in patients with abdominal spirometry. Manganas et al.(25) found no association between the severity of airflow obstruction and postoperative complications after elective coronary artery bypass grafting. Abnormal chest radiographs showed a statistically significant difference in the study by Garg et al(18).; however, this was not observed in our study.

The limitations of this study include its observational and single-center design, which may limit the generalizability of the findings. The study population was heterogeneous, encompassing multiple surgical specialties with differing baseline risks for postoperative pulmonary complications. Data on intraoperative ventilatory parameters were not recorded, and pulmonary function tests were missing for a proportion of patients. Case-control analysis was not done to compare patients without respiratory co-morbid conditions.

Conclusion:

In this single-center observational study of surgical patients with pre-existing or suspected respiratory disease, the overall incidence of postoperative pulmonary complications (PPCs) was 25.6%, aligning with reported rates in similar high-risk populations . Hypoxia, respiratory failure, atelectasis, and exacerbations of underlying lung disease were the most common PPCs. Preoperative steroid use showed no statistically significant association with PPCs overall; however, subgroup analysis revealed a trend toward lower complication rates in patients with COPD receiving steroids, Although abnormal chest X-ray findings were common (37.1%), they were not independently associated with PPCs overall,Furthermore, spirometry results (FEV_1 % predicted) were also not predictive of PPCs in this cohort, suggesting that imaging and spirometry alone may be insufficient for risk stratification without functional assessment.

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